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Evaluation of Two Dental Implant Systems After at Least One-Year of Loading: A Clinical Follow-Up: Case Control Research

En Az Bir Yıllık Yüklemeden Sonra İki Farklı İmplant Yüzeyinin Değerlendirilmesi: Klinik Takip: Olgu Kontrol Araştırması

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ABSTRACT Objective: The purpose of this study was to compare and examine the two different implant surfaces clinically and radiographically in function. The clinical success of implants is closely related to osteointegration of the implants. Implants surface properties are closely related to the osteointegration. To evaluate the success and survival of the implant-supported prostheses, clinical and radiographic findings are used. **Material and Methods:** Total of 79 patients in need of dental implant were enrolled. They were randomly assigned. 100 TiUnite® surface and 129 SLA® surface were used. Baseline, 6-month, 12-month and 18-month measurements included bone loss, pocket depth, plaque, and bleeding index were evaluated. Baseline and prior to the prosthetic reconstruction affected the implant stability quotient determined by the resonance frequency analysis. All the above data was used for the evaluation of implant survival and success. **Results:** The overall survival rate of the implants was 100% and the relevant success rate was 97.8%. The technical complication rate was 0.44% due to the superstructure porcelain fracture in one implant. The breakdown of the success rate within the implants was 98.0% for TiUnite® implant, 99.2% for the SLA® implant. **Conclusion:** Implant surfaces were important in survival rate for the clinical success for the osteointegration in long term period. These two implant surfaces would be chosen for the clinically long-term successful and survival rate.

Keywords: Implant surface; marginal bone loss; resonance frequency analysis; success and survival rate

ÖZET Amaç: Bu çalışmanın amacı, 2 farklı implant yüzeyinin implantlar fonksiyondayken hem klinik ve radyolojik incelemelerinin karşılaştırıp değerlendirilmesidir. İmplantların klinik başarısı implantların osteointegre olmasıyla yakından ilgilidir. İmplant yüzey özelliği de osteointegrasyonla yakından ilişkilidir. İmplant destekli protezlerin sağkalım ve başarı kriterleri belirlemek için klinik ve radyolojik incelemeler yapılmaktadır. **Gereç ve Yöntemler:** Toplam 79 hastaya implant uygulandı. Hastalar karışık olarak seçildi. 100 TiUnite® yüzeyi ve 129 SLA® yüzey implant uygulandı. İlk uygulama anı, 6 aylık, 12 aylık, 18 aylık süreçlerde kemik kaybı, cep derinliği, plak ve kanama indeksi ölçüldü. Cerrahi işlem sonrasında ve protetik restorasyon öncesi alınan rezonans frekans analizi ile implant stabilitesi kontrol edildi. Tüm elde edilen sonuçlar implant sağkalım ve başarı karşılaştırmasında kullanıldı. **Bulgular:** Implantların sağkalım oranı %100 iken başarı oranı %97,8'dir. Bir implantta meydana gelen porselen kırığından dolayı %0,44 oranında teknik komplikasyon hesaplandı. İki farklı yüzeyin kendi içindeki başarı değerleri TiUnite® implantta %98,0, SLA® implantta %99,2 bulundu. **Sonuç:** Uzun klinik başarılarda ve implantların sağkalım oranlarını artırmakta önemli olan osteointegrasyonda implant yüzey özellikleri önemlidir. Her iki implant yüzeyi de klinik başarı ve uzun dönem sağkalım için seçilebilir.

Anahtar Kelimeler: İmplant yüzeyi; marjinal kemik kaybı; rezonans frekans analizi; sağkalım ve başarı oranları

Dental implants are a reliable treatment option for partially or fully edentulous patients.[1] However, osseointegration is required for the long-term survival and success of implants, and its success depends on implant variables such as the material, design, length, diameter and chemical properties of the implant, as well as the implant's surface features.[2]

Rough implant surfaces were reported to have a significant increase in bone-to-implant anchorage, and improving osseointegration may be achieved by applying physical or chemical procedures to increase the roughness of the implant surface.[3-5] Physical methods for roughening include machining, cutting, titanium plasma spraying, blasting, and polishing.[6]

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Acid roughening for modifying the chemical structure of titanium, particularly the surface layer, plasma spray coating, blasting, hydroxyapatite coating, roughening by anodization, and similar techniques of chemical methods for roughening are also used.[3-5] Furthermore, some implant surfaces use acidification with blasting as a surface treatment.[3]

Reliable measurements are required to determine the success of osseointegration and both invasive and noninvasive techniques have been developed.[7] Invasive techniques include histological analysis and reverse torque tests, whereas noninvasive techniques include radiographic evaluations, cutting resistance, percussion tests, and implant mobility tests.[8-13] Resonance frequency analysis (RFA) has also gained popularity due to its quantitative nature and data that provides estimates of implantation time.[14,15]

Implant surface differences affect osseointegration and the long-term implant survival rate. SLA® (Straumann: Institute Straumann AG, Basel, Switzerland) implants have a 1.8 μ surface roughness for the entire implant, which positively affects osseointegration ability over time. In TiUnite® (Nobel: Nobel BioCare AG, Gothenburg, Sweden) implants, surface roughness is increased through the apical, which is approximately 1.2 μ, which helps with immediate loading and primer stability.[3-5] In this study, the aim was to examine and compare the clinical success of these two dental implant systems using RFA, radiographic parameters, and peri-implant measurements.

Our null hypothesis was; the clinical survival rates of implants with different surfaces will be equal or close to each other at least one year of loading.

MATERIAL AND METHODS

This study was followed up at the Department of Prosthodontics and The Department of Oral and Maxillofacial Surgery, Faculty of Dentistry in Kocaeli, Türkiye. The study was approved by the Kocaeli University Health Science Department Ethics Board with the clinical study protocol Ref. No KOU KAEK 2015-205 (date: July 28, 2015) and followed the Declaration of Helsinki on medical protocol and ethics.

The study included individuals older than 18 years of age who were literate and whose systemic health were classified according to the American Society of Anesthesiologists (ASA) as ASA-1 or ASA-2.[16] Seventy-nine patients (38 males and 41 females; mean age=51 years; range=21-82 years) in need of dental implant therapy with fixed and removable dental prostheses were recruited. Each patient signed written, informed consent before taking part in the study. The clinical and radiographic data of 229 implants were evaluated; 100 implants had TiUnite® surfaces, and 129 implants had SLA® surfaces.

The prosthetic procedures followed the guidelines of the related implant system. Fixed partial dentures or removable prostheses were prepared according to the clinician's decision. The 3 months following the implantation of a permanent prosthesis was used as the baseline for the assessment of clinical parameters. The follow-up examinations were performed 6 months and 12 months after the baseline examinations.

An Osstell™ (Integration Diagnostics AB, Gothenburg, Sweden) device was used to measure the implant stability quotient (ISQ). The initial ISQ values of the implants were measured following surgery and immediately before the healing cap was placed. The second ISQ measurements were taken 1 month after the implantation or during the session where the healing cap was changed to gingival former during second surgeries. Measurements were obtained by positioning the measuring tip of the device perpendicular to the mounted Smart Peg (a small aluminum rod, Type 4, 53 and 54 for SLA® surfaces and Type 60 and 61 for TiUnite® surfaces) from the mesial and buccal direction. Each measurement was taken three times, and the mode was recorded. The mean ISQ value of an implant was calculated by averaging the mesial and buccal measurements from the ISQ unit. ISQ measurements were completed with clinical and radiographic controls, and prosthetic procedures were initiated for patients with sufficient osseointegrations.

The health of the peri-implants following restorations were evaluated using the plaque and bleeding indexes, and probable pocket depth. Initial and final measurements were evaluated at the 3-month and 15-month follow-up period.

To determine the mesial, distal, and mean bone loss around an implant, parallel technique radiographs were taken immediately after the implant surgery and at the 6-months intervals following surgery and transferred to a computer. The amount of mesial and distal alveolar bone loss seen in the radiographs were calculated using Photoshop CC (Adobe Photoshop CC 2017, USA). To obtain the marginal bone level, an enlargement ratio of each image was calculated from the manufacturer-specified thread pitch of each implant system. The distance from the first thread (reference point) to the level of the alveolar bone crest was measured on the mesial and distal surfaces of the implant and converted to the actual value using the enlargement ratio. This value was then compared with measurements taken at 6 months, 12 months and 18 months after surgery.

Success rates were determined in accordance with the criteria defined at the International Congress of Oral Implantologists (ICOI) in 2007.[1] Accordingly, implants that did not cause clinical pain/sensitivity during functioning, or have a history of exudation, with no mobility, and that had been functioning for at least 1 year with less than 2 mm of bone loss were classified as successful.

Statistical analyses were performed using SPSS 22.0 (IBM SPSS, Türkiye), and the significance level for all tests was $p<0.05$. The normality of the quantitative data was tested using the Shapiro-Wilk test. Student's t-tests were used to compare variables with normal distributions between the two implant groups, and the Mann-Whitney U test was used to compare non-normal variables in the two groups. Correlations between categorical variables was tested using the chi-square test. Paired t-tests were used to analyze bone loss in all of the implants. ISQ values and patient satisfaction values between the two implant groups were analyzed using Student t-tests. Friedman's two-way analysis of variance was used to make pocket depth comparisons for all of the implants and to calculate the bleeding and plaque indexes. Pairwise Testing was used for a sectional comparison of all implant pockets. The Wilcoxon signed-rank test was used to compare the pockets between the implants.

RESULTS

Overall, 79 patients received 229 implants. Forty-six patients received 100 implants with TiUnite® surfaces, and 33 patients received 129 implants with SLA® surfaces. All implants were implanted on type 2 or 3 bone. Two hundred and nineteen (95.6%) implants were placed in healed extraction sockets, and for 10 (4.4%) immediate implant placement was performed in the extraction sockets during the implant surgery. Fifteen (6.6%) of the 229 implants were treated with immediate loading, whereas late loadings were performed on the remaining 214 (93.4%). One hundred and eighty-two (79.2%) implants were between 10 mm and 12 mm high (10 mm, 11.5 mm and 12 mm). Eighty-three narrow diameter implants (3.3 mm and 3.75 mm), 125 standard diameter implants (4.1 mm and 4.3 mm), and 21 wide diameter implants (4.8 mm, 5.0 mm and 5.5 mm) were used. Twenty-two implants (9.6%) were restored with removable prostheses, and 207 (90.4%) were restored with fixed prostheses.

Single crowns were used for 54 (23.6%) definitive restorations, splint crowns for 24 (10.5%), fixed partial dentures for 99 (43.2%), mesial cantilever restorations for 18 (7.9%), and full arch fixed prostheses for 12 (5.2%) restorations were used. One hundred and ninety-nine (86.9%) of the restorations were performed using porcelain fused to metal (PFM), 8 (3.5%) with porcelain fused to zirconia, and 22 (9.9%) with polymethyl methacrylate material. One hundred and eighty-two (79.5%) of the restorations were cemented, 25 (10.9%) were screw-retained, and 22 (9.6%) were overdenture prostheses. Implant supported restorations were antagonist to 131 (57.2%) natural teeth, 25 (10.9%) with tooth-supported PFM, 61 (26.6%) with implant-supported PFM restorations, and 12 (5.2%) with complete dentures.

No significant difference was found between the first and the second ISQ values in the group with the TiUnite® surface implant system ($p>0.05$). In contrast, the second measurements of the mean ISQ values in the group with the SLA® surfaces were significantly higher compared to the first measurements ($p=0.010$). Values are shown in the Table 1. The final pocket depth measurements from all direc-

TABLE 1: ISQ measurements of implants.

	Type of implant					
	SLA® surfaces implant system			TiUnite® surfaces implant system		
Duration	n	Mean (ISQ)±SD	p value*	n	Mean (ISQ)±SD	p value*
T1	129	73.8±9.8	0.010*	100	74.7±6.8	0.230
T2	129	75.7±6.2		100	75.5±5.2	

*p value <0.05; Area, the radiographic measurement area of calculation of marginal bone loss; ISQ: Implant stability quotient; SD: Standard deviation; T1: First ISQ measurement at surgery; T2: Second ISQ measurement before the prosthetic procedure. (Student t-tests).

tions for both the TiUnite® and SLA® surface implants were significantly higher than at baseline (p=0.001). The final bleeding index of the TiUnite® surface implants were also significantly higher than baseline (p=0.001). However, there was no significant difference between baseline and final bleeding index measurements for the SLA® surface implants (p=0.690). In contrast, the final plaque index measurements of the TiUnite® surface implants were significantly higher than baseline (p=0.001), while there was no significant difference between baseline and final plaque index measurements of the SLA® surface implants (p=0.784).

The average marginal bone loss from the baseline values for the SLA® and TiUnite® implants were 0.15±0.39 mm and 0.35±0.36 mm after 6 months; 0.25±0.49 mm and 0.62±0.36 mm after 12 months and; 0.40±0.62 mm and 0.71±0.59 mm after 18 months, respectively. As shown in Table 2, there were no significant differences found for mesial or distal marginal bone loss surrounding either implant system (p>0.05). As shown in Table 3, progressively increasing marginal bone loss occurred during the observation period for both implant systems (p=0.001).

No implant loss was observed during the study. The survival rate of the implants after 15 months of

TABLE 2: Mesial and distal marginal bone loss around the implant systems.

		Type of implant					
		SLA® surfaces implant system			TiUnite® surfaces implant system		
Duration	Area	n	Mean (mm)±SD	p value*	n	Mean (mm)±SD	p value*
During the 6 months after surgery	Mesial	129	0.17±0.46	0.159	100	0.33±0.36	0.095
	Distal	129	0.14±0.32		100	0.38±0.36	
During the 12 months after surgery	Mesial	129	0.28±0.58	0.128	100	0.64±0.19	0.075
	Distal	129	0.23±0.39		100	0.61±0.52	
During the 18 months after surgery	Mesial	129	0.43±0.76	0.279	100	0.66±0.59	0.054
	Distal	129	0.38±0.48		100	0.77±0.59	

*p value <0.05; Area, the radiographic measurement area of calculation of marginal bone loss; SD: Standard deviation. (Paired t-tests).

TABLE 3: Mesial and distal marginal bone loss around the both implant systems.

Duration	Area	n	Mean (mm)±SD	p value*
During the 6 months after surgery	Mesial	229	0.24±0.43	0.912
	Distal	229	0.25±0.36	
During the 12 months after surgery	Mesial	229	0.52±2.16	0.360
	Distal	229	0.40±0.49	
During the 18 months after surgery	Mesial	229	0.53±0.70	0.593
	Distal	229	0.55±0.56	

*p value <0.05; Area, the radiographic measurement area of calculation of marginal bone loss; SD: Standard deviation. (Paired t-tests).

functioning was 100%. According to the implant success criteria defined by the ICOI (bone loss <2 mm, mobility (-), pain/sensitivity during function (-), no history of exudation), the success rate was 98.7%. When evaluated separately, success was 98.0% for the TiUnite® and 99.2% for the SLA® implant systems. With the exception of a superstructure porcelain fracture in one implant, no complications were observed for either the infrastructure or the abutment. Hence, the prosthetic complication rate was calculated as 0.44%.

DISCUSSION

The present study aimed to examine and compare the clinical success of two dental implant systems that use SLA® or TiUnite® surfaces with RFA, radiographic parameters and peri-implant measurements. For both systems, the mean changes in the functional bone level were <1 mm at the mesial and distal positions after 1 year of follow-up. The general pattern of ISQ changes was similar across both implant systems at the end of the osseointegration period. The ISQ values of each group were consistent and without decreases during the first 4 weeks after surgery. However, in studies evaluating implant stability using RFA, a significant decrease has been observed in ISQ values after implantation.[17-22] Ersanli et al. reported that declines occurred within 3 to 6 weeks, while Barewal et al. reported declines in week 3, and Huwiler et al. observed declines within 2 to 4 weeks.[18,19,21] Monov et al. reported that a significant decrease in ISQ values occurred very early, such as 4 days after implantation.[20] Although, in all of these studies decreases that occurred in the ISQ values increased over the subsequent weeks as recovery progressed. The researchers suggested that reductions in the stability values and their subsequent increases was caused by the change from callus to mature bone during the healing process.[18,20,23] A decrease in mechanical stability occurs during the remodeling of the bone and, hence, a decrease in ISQ values.[18,20,21,23] Glauser et al., in a 4-year study in which they evaluated bone loss and RFA in 102 Brånemark implants with 38 patients, found a decrease in RFA measurements within the first 4 weeks following implantation.[24] However, they reported an increase at the end of 1 year compared to baseline stability. Bischof et al. performed immediate and late loadings on Type 1, 2, and 3 bones on the ITI Dental Implant System (Straumann AG Waldenburg, Switzerland) with SLA® surfaces and found that the mean ISQ values remained stable or increased up to 4-6 weeks during the recovery period, after which a significant increase was observed.[23] In our study, which is similar to that of Bischof et al., no significant difference was found between the first and the second ISQ values in the group with TiUnite® implant system ($p>0.05$).[23] However, the second Osstell ISQ measurements of the SLA® surface implant system had values that were significantly higher in comparison to the initial measurements ($p=0.010$). It was thought that implant surface differences affected osseointegration. In SLA® implants there is a 1.8μ surface roughness over the entire implant, which increased osseointegration ability over time. In contrast, in TiUnite® implants, the surface roughness is increased through the apical, which is approximately 1.2μ, which helps with immediate loading and primer stability. In our study second measurements were made in the 4 weeks to wait the maturation of the bone in order to be more realistic for the implant surface differences. Therefore, the first and second measurements with the Osstell were approximately the same due to this primary stability.

The pocket measurements around the tooth and the implant were not fully comparable given the connection with the implant mucosa due to the soft tissue components and their remodeling.[25-27] However, if the tissues around the implant were healthy, the attachment of the periodontal probe and supracrestal attachment tissue would be at the biological level.[28] In the 1-year study by Tolentino et al. comparing titanium-zirconium alloys (TiZr) and titanium (CpTi) the mean bone loss at 6 months and 1 year, bleeding at probing, pocket depth, and success and survival rate factors were evaluated.[29] The mean pocket depth was measured for TiZr and CpTi at 6 weeks and showed a statistically significant difference ($p<0.05$); however, the 1-year mean pocket depth measurements were not significantly different ($p>0.05$). Furthermore, the authors found that the implant circumference probing results were approximately 0.5 mm higher than the opposite side of the control teeth. Commonly, the buccal and lingual surfaces of im-

plants have a pocket depth of 0.5-1 mm less than the proximal surfaces. However, standard pocket depth in dental implants can vary depending on the implant system used. Christensen et al. has reported a typical pocket depth of 3-3.5 mm for ITI implants. In our study, the SLA® implants' initial and final pocket depths were measured as 2.28±0.68 mm and 2.97±0.62 mm, respectively.[27] Although there was a significant increase in pocket depth over time, it was not statistically significant for any of the surfaces. The buccal measurements of the TiUnite® and SLA® surface implants were significantly lower than the other sites ($p<0.05$). It was thought that these changes occurred because the patients were better able to clean the surfaces if they could easily see them.

Radiography has been reported to be a fast and noninvasive method for evaluating bone changes surrounding implants.[30,31] In many studies that have assessed bone loss around an implant after surgery, standardized intraoral radiographs have been used with parallel techniques and film holders, which was used to assess the changes in the marginal bone level in our study.[30-32] Radiographs were obtained during the first week and at 6, 12 and 18 months after surgery and recorded marginal bone level changes on the mesial and distal surfaces of the implants. The average marginal bone loss from the baseline of implant placement for the SLA® surfaces and TiUnite® surfaces implants were 0.15±0.39 mm and 0.35±0.36 mm after 6 months; 0.25±0.49 mm and 0.62±0.36 mm after 12 months and 0.40±0.62 mm and 0.71±0.59 mm after 18 months respectively. They were not significantly difference but the value of TiUnite® is higher than the SLA® it was thought that in the first year SLA surface's osseointegration was better in our study.

Ebler et al. determined that the success rate for Astra Tech Astra Tech (Astra Tech AB, Mölndal, Sweden) and Straumann (Institut Straumann AG, Basel, SWi) implants was 81.5% and 95.3%, respectively, and only technical complications were encountered with Astra Tech at a rate of 12%.[33] The rate of biological complications was 6% and 3.2% for Astra Tech and Straumann respectively, but no statistically significant difference was observed ($p>0.05$). The rates of bone loss observed at the end of 1-year were 0.49 mm in Astra Tech and 0.34 mm in Straumann implants. However, peri-implantitis with a bone loss of more than 2 mm was only observed in the Astra Tech implants. In the same study, bleeding on probing was observed in 2 Astra Tech and 1 Straumann implant. In a 1-year study by Tolentino et al., the implants of narrow-diameter TiZr and CpTi were compared. Mean bone loss at 6 months and 1 year, bleeding on probing, pocket depth, and success and survival rate factors were evaluated.[29] Using Karoussis's success criteria, the success and survival rate was 95.2%.[30] In another study by Tolentino et al. that investigated TiZr and CpTi implants in 10 patients during the course of a 1-year clinical trial, the authors determined the survival rate to be 100% based on the criteria of Karoussis.[30-35] According to this study, which also investigated periodontal evaluation as a success criterion, the success rate decreased over time. In our study, the success rate of the TiUnite® and SLA® implants after 15 months was 98% and 99.2%, respectively. However, increased pocket depth and loss of clinical attachment may be a sign of periodontal disease. Therefore, although pocket depth measurements were not included in the final implant success criteria, it is useful to compare the initial pocket measurement values with future clinical assessments. In our study the final plaque and bleeding index measurements of the TiUnite® surfaces implants were significantly higher than the baseline measurements ($p=0.001$). It was thought that it could be happened because of the personal hygiene habits.

The limitation of our study was the short follow-up period. However, the first six months following surgery are the most critical in implantology. Also various restorations type could effect the marginal bone lost these could be seen by the long term clinical appointments.

CONCLUSION

The overall survival rate of the implants in this study was 100%, and the success rate was 97.8%. Separately, the success rate was 98.0% for the TiUnite® implant and 99.2% for the SLA® implant. Implant surfaces are important for osseointegration over the long term. Immediate loading, bone structure, and pa-

tient oral hygiene should be considered when choosing implants that will be clinically successful.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

All authors contributed equally while this study preparing.

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